IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of:

ZHIKUAN WANG et al.

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For: METHOD FOR PRODUCTION OF ALKALI METAL CHROMATES

DECLARATION UNDER 37 C.F.R. §1.132

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Sir:

1. I am Shili Zheng, a citizen of People's Republic of China, having residence at Institute of Process Engineering, Chinese Academy of Sciences, Beiertiao 1, Zhongguancun, Beijing, 100190, China, hereby declares as follows:

2. I received my Bachelor's and Master's Degree in Chemistry from Central South University in 1994 and 1997, respectively, and my Doctor's Degree in Chemical Technology from Institute of Process Engineering, Chinese Academy of Sciences in 2000.

3. I am a professor in Institute of Process Engineering, Chinese Academy of Sciences (http://www.ipe.cas.cn).

4. During the past several years, I have jointly authored the following peer-reviewed publications that have been published and placed in international circulation:

(1) Wei Jin, Hao Du, **Shili Zheng**, Hongbin Xu, and Yi Zhang. Comparison of the Oxygen Reduction Reaction between NaOH and KOH solutions on a Pt Electrode: the Electrolyte-Dependent Effect. ***The Journal of Physical Chemistry. B.*** 114: 6542-6548, 2010 (corresponding author)

(2) Wei Jin, **Shili Zheng**, Hao Du, Hongbin Xu and Yi Zhang. Isopiestic Study of the Na_2CrO_4–H_2O System at 353.15 K: Prediction of the Solubility of Na_2CrO_4 in Aqueous NaOH Solutions. ***Ind. Eng. Chem. Res.***, 49 (17): 8244-8247, 2010 (corresponding author)

(3) Ying Zhang, **Shili Zheng**, Hao Du, Shaona Wang, and Yi Zhang. Solubility of Al_2O_3 in the Na_2O-Al_2O_3-H_2O-CH_3OH System at (30 and 60) ℃. ***Journal of Chemical and Engineering Data***. 55: 1237-1240, 2010 (corresponding author)

(4) Yang Zhang, **Shili Zheng**, Hongbin Xu, Hao Du ,Yi Zhang. Decomposition of chromite ore by oxygen in molten NaOH-$NaNO_3$. ***International Journal of Mineral Processing***, 95: 10-17, 2010 (corresponding author)

(5) Wei Jin, **Shili Zheng**, Hao Du, Hongbin Xu, Shaona Wang, and Yi Zhang. Phase Diagrams for the Ternary Na_2O-Al_2O_3-H_2O System at (150 and 180) °C. ***J. Chem. Eng. Data***, 55 (7): 2470-2473, 2010 (corresponding author)

(6) Yang Zhang, **Shili Zheng**, Hongbin Xu, Hao Du, Yi Zhang. Phase equilibria in the NaOH-Na_2CrO_4-Na_2CO_3-H_2O system. ***J. Chem. Eng. Data***, 55 (7): 2542-2545, 2010 (corresponding author)

(7) Yang Zhang, **Shili Zheng**, Hongbin Xu, Hao Du, Yi Zhang. Phase equilibria in the NaOH-$NaNO_3$-Na_2CrO_4-H_2O system. ***J. Chem. Eng. Data***, 2010, 55 (9): 3029-3031 (corresponding author)

(8) Wang, Shaona; Song, Ziwei; Zhang, Yan; Du, Hao; **Zheng, Shi-Li**; Zhang, Yi. Solubility Data for the NaOH–$NaNO_3$–Na_3VO_4–Na_2CrO_4–H_2O System at (40 and 80) °C. ***J. Chem. Eng. Data***, 55 (11): 4607–4610, 2010 (corresponding author)

(9) Xiaohui Wang, **Shili Zheng**, Hongbin Xu, Yi Zhang. Leaching of niobium and tantalum from a low-grade ore using a KOH roast–water leach system. ***Hydrometallurgy***. 98: 219-223, 2009 (corresponding author)

(10) Ying Zhang, **Shili Zheng**, Hao Du, Hongbin Xu, Shaona Wang, Yi Zhang. Improved precipitation of gibbsite from sodium aluminate solution by adding methanol. ***Hydrometallurgy***, 98: 38-44, 2009 (corresponding author)

(11) Zhi Sun, Yi Zhang, **Shi-Li Zheng**, Yang Zhang. A new method of potassium chromate production from chromite and KOH-KNO_3-H_2O binary sub-molten salt system. ***AIChE Journal***, 55(10): 2646-2656, 2009

(12) Ying Zhang, **Shili Zheng**, Hao Du, Shaona Wang, and Yi Zhang. Solubility of Al_2O_3 in the Na_2O-Al_2O_3-H_2O-CH_3OH System at 30 °C and 60 °C. ***Journal of Chemical and Engineering Data***, 98: 38-44, 2009 (corresponding author)

(13) Xiaohui Wang, **Shili Zheng**, Yi Zhang, A novel method to prepare ultrafine potassium tantalate powders, ***Materials Letters***, 62(8~9):1212~1214, 2008 (corresponding author)

(14) Shaona Wang, **Shili Zheng**, and Yi Zhang, Stability of $3CaO.Al_2O_3.6H_2O$ in KOH+K_2CO_3+H_2O system for chromate production, ***Hydrometallurgy***, 90(2): 201-206, 2008 (corresponding author)

(15) Zhi Sun, **Shi-li Zheng**, Hong-bin Xu, Yi Zhang, Oxidation decomposition of chromite ore in molten potassium hydroxide, ***International Journal of Mineral Processing***, 83: 60-67, 2007 (corresponding author)

(16) Shuhua Ma, **Shili Zheng**, Yifei Zhang and Yi Zhang, Phase Diagram for the Na_2O-Al_2O_3-H_2O System at 130℃, ***Journal of Chemical and Engineering Data***, 52: 77-79, 2007 (corresponding author)

(17) Sun Zhi, **Zheng Shi-Li,** Zhang Yi. Investigation of efficient conditions for oxidative roasting of chromite ore to produce potassium chromate with KOH additive, ***Steel Research International***, 78(7): 574-576, 2007 (corresponding author)

(18) **Shi-li Zheng**, Yi Zhang, Zuo-hu Li, Tao Qi, Hui-quan, Li, Hong-bin Xu. Green metallurgical processing of chromite. ***Hydrometallurgy***, 82: 157-163, 2006

(19) Shaona Wang, **Shili Zheng**, and Yi Zhang, Vapor Pressure Determination of the KOH+K_2CrO_4+H_2O System, ***Journal of Chemical & Engineering Data***, 51(3): 851-853, 2006 (corresponding author)

(20) Chunhua Du, **Shili Zheng**, Huiquan Li, and Yi Zhang. Solid-liquid equilibria of K_2CO_3 + K_2CrO_4 + H_2O System. ***Journal of Chemical and Engineering Data***, 51: 104-106, 2006

(21) Chunhua Du, **Shili Zheng**, Yi Zhang. Phase equilibria in the K_2O-Al_2O_3-H_2O system at 40℃. ***Fluid Phase Equilibria***, 238: 239-241, 2005 (corresponding author)

(22) Hongming Zhou, **Shi-li Zheng**, Yi Zhang, Dan-qing Yi. A kinetic study of the leaching of a low-grade niobium–tantalum ore by concentrated KOH solution. ***Hydrometallurgy***, 80: 170-178, 2005

(23) H.-B. Xu, **S.-L. Zheng**, Y. Zhang, Z.-H. Li and Z.-K. Wang, Oxidative leaching of a Vietnamese chromite ore in highly concentrated potassium hydroxide aqueous solution at 300℃ and atmospheric pressure. ***Minerals Engineering***, 18: 527-535, 2005

(24) Yi Zhang, Zuohu Li, Tao Qi, **Shili Zheng**, Huiquan Li, Hongbin Xu. Green manufacturing process of chromium compounds. ***Environmental Progress***, 24 (1): 44-50, 2005

(25) Hongming Zhou, Dan-qing Yi, Yi Zhang, **Shi-li Zheng**. The dissolution behavior of Nb_2O_5, Ta_2O_5 and their mixture in highly concentrated KOH solution. ***Hydrometallurgy***, 80: 126-131, 2005

(26) Hongming Zhou, **Shili Zheng**, Yi Zhang. A new way of synthesis of non-linear optical potassium niobate powder. ***Journal of Materials Science***, 39(13): 4359-4361, 2004 (corresponding author)

(27) Hong-Bin Xu, Yi Zhang, Zuo-Hu Li, **Shi-Li Zheng**, Zhi-Kuan Wang, Tao Qi, Hui-quan Li. Development of a new cleaner production process from chromite ore to chromic oxide. ***Journal of Cleaner Production***, 14: 211-219, 2004

5. During the past several years, I have jointly prepared and given the following listed presentations at international conferences:

(1) **Shili Zheng**, Yi Zhang, Zuohu Li, Tao Qi, Huiquan Li, Hongbin Xu, Green Hydrometallurgy Process of chromite, The 2004's international conference on hydrometallurgy (ICHM2004), Xi'an, China, 2004.10

(2) **Shili Zheng**, Yi Zhang, Tao Qi, Huiquan Li, Hongbin Xu, Application of "3R Principles" in Chromate Production, 7th Word Congress on Recovery, Recycling and Re-integration, Beijing, China, 2005.9 (keynote)

6. I have been practicing in this field for approximately 13 years.

7. I am one of the inventors for the present invention "METHOD FOR PRODUCTION OF ALKALI METAL CHROMATES".

8. The invention of "METHOD FOR PRODUCTION OF ALKALI METAL CHROMATES" has been successfully applied into industry, and has received the second prize in the Chinese National Technology Invention in 2005. The related study has been published in over sixty research articles and applied for more than ten patents in China, including:

Research Articles:

(1) Yi Zhang, Zuo-Hu Li, Tao Qi, Shi-Li Zheng, Hui-Quan Li, Hong-Bin Xu. Green manufacturing process of chromium compounds. Environmental Progress, 2005, 24 (1): 44-50.

(2) Yi Zhang, Zuo-Hu Li,Tao Qi, Zhi-Kuan Wang, Shi-Li Zheng. Green chemistry of chromate cleaner production. The Chinese Journal of Chemistry, 1999, 17 (3): 258-266, 202.

(3) S. Zheng, Y. Zhang, Z. Li, T. Qi, H. Li, H. Xu. Green metallurgical processing of chromite. Hydrometallurgy, 2006, 82: 157-163.

(4) Hong-Bin Xu, Yi Zhang, Zuo-Hu Li, Shi-Li Zheng, Zhi-Kuan Wang, Tao Qi, Hui-Quan Li. Development of a new cleaner production process for producing chromic oxide from chromite ore. Journal of Cleaner Production, 2006, 14 (2): 211-219.

(5) Ping Li, Hong-Bin Xu, Shi-Li Zheng, Yi Zhang, Zuo-Hu Li, Yu-Lan Bai. A green process to prepare chromic oxide green pigment. Environmental Science & Technology, 2008, 42 (19): 7231-7235.

(6) Xing Zou, Yi Zhang. Cleaning of chromate manufacture process. Journal of University of Science and Technology Beijing, 2000, 7 (2): 132-134.

(7) Z. Sun, S.L. Zheng, Y. Zhang. Thermodynamics study on the decomposition of chromite with KOH. Acta Metallurgical Sinica, 2007, 20 (3): 187-192.

(8) Dawei Cao, Yongjie Zhang, Tao Qi, Jinglong Chu, Lina Wang, Yi Zhang. Phase diagram for the system $K_2Cr_2O_7$ + CrO_3 + H_2O at (25 and 90) °C. Journal of Chemical and Engineering Data, 2007, 52: 766-768.

(9) Ge Xinlei, Wang Xidong, Zheng, Shili, Zhang Mei, Zhang Yi. Phase relationship of complex multi-component system in chromate cleaner production. Progress in Natural Science, 2007, 17 (7): 845-850.

(10) Chunhua Du, Shili Zheng, Huiquan Li, Yi Zhang. Solid-liquid equilibria of K_2CO_3 + K_2CrO_4 + H_2O System. Journal of Chemical and Engineering Data, 2006, 51 (1): 104-106.

(11) Shaona Wang, Shili Zheng, Hongbin Xu, Yi Zhang. Vapor pressure determination of the KOH+K_2CrO_4+H_2O System. Journal of Chemical and Engineering Data, 2006, 51 (3): 851-853.

(12) Wang Jiong, Xu Hongbin, Zhang Songpei, Zhang Yi. Solubilities of the K_2CrO_4-CH_3OH/C_2H_5OH-H_2O system. Inorganic Chemicals Industry, 2006, 38 (8): 20-22.

(13) Chunhua Du, Shili Zheng, Yi Zhang. Phase equilibria in the K_2O–Al_2O_3–H_2O system

at 40℃. Fluid Phase Equilibria, 2005, 238: 239-241.

(14) Heng-fang Chen, Zuo-hu Li, Yi Zhang. Solubility in the $K_2Cr_2O_7$ + CrO_3 + KNO_3 + HNO_3 + H_2O system. Journal of Chemical and Engineering Data, 2004, 49 (1): 143-147.

(15) Xidong Wang, Jinlan Cui, Xinlei Ge, Shili Zheng, Mei Zhang, Yi Zhang. Thermodynamic study of K_2CrO_4-$KAlO_2$-KOH-H_2O and Na_2CrO_4-$NaAlO_2$- NaOH-H_2O systems. Journal of University of Science and Technology Beijing, 2004, 11 (6): 500-504.

(16) S.L. Zheng, Y. Zhang. Thermodynamic study of chromite caustic fusion process. Acta Metallurgical Sinica, 2001, 14 (1): 47-55.

(17) Jin-lan Cui, Yi Zhang. Study on the KOH + K_2CrO_4 + K_2CO_3 + H_2O System. Journal of Chemical and Engineering Data, 2000, 45 (6): 1215-1217.

(18) Jin-lan Cui, Yi Zhang. Solubility in the Na_2CrO_4 + $(NH_4)_2CrO_4$ + $NaHCO_3$ + NH_4HCO_3 + H_2O System. Journal of Chemical and Engineering Data, 2000, 45 (2): 257-259.

(19) Cui Jinlan, Zhang Yi, Liu Changjian. Phase Diagrams of Na_2CrO_4-$(NH_4)_2CrO_4$-H_2O sytem. Acta Physico-Chimica Sinica, 2000, 16 (1): 70-75.

(20) LIU Chang-jian, ZHANG Yi. Solubility of Na^+//CrO_4^{2-}, HCO_3^--H_2O system by three parameter Pitzer model and experimental verification. Engineering Chemistry & Metallurgy, 2000, 21 (1): 6-9.

(21) ZOU Xing, ZHANG Yi. Phase diagram of the Na_2O-CrO_3-Al_2O_3-H_2O quaternionic system with high Na_2O content. Engineering Chemistry & Metallurgy, 2000, 21 (3): 248-251.

(22) Zheng Shili, Zhang Yi. Thermodynamic analysis on new reaction system of liquid phase oxidation of chromite in molten salt. The Chinese Journal of Nonferrous Metals, 1999, 9 (4): 800-804.

(23) CUI Jinlan, ZHANG Yi. Study on solubilities and properties of solution in Na_2CrO_4-

$NaHCO_3$-H_2O system. ACTA METALLURGICA SINICA, 1999, 35 (10): 1062-1064.

(24) ZHENG Shi-Li, ZHANG Yi, CUI Jin-Lan. Thermodynamic calculation software and its application. Computers and applied chemistry, 1998, 15 (6): 373-377.

(25) ZOU Xing, ZHANG Yi, LI Zuohu, HAN Qiyong. Phase equilibria of NaOH-$NaAlO_2$-Na_2CrO_4-H_2O saline system. Engineering Chemistry & Metallurgy, 1998, 19 (2): 118-121.

(26) Xu Xia, Zhang Yi, Wang Zhikuan. Thermodynamical analysis of the process of liauid-phase oxidation of chromite. Engineering Chemistry & Metallurgy, 1996, 17 (1): 19-25.

(27) ZHANG Yang, SUN Zhi, ZHENG Shili, ZHANG Yi. Experimental study on chromite ore decomposition by KOH-KNO_3 binary sub-molten salt. Chemical industry and engineering progress, 2008, 27 (7): 1042-1047.

(28) Zhi Sun, Shi-li Zheng, Hong-bin Xu, Yi Zhang. Oxidation decomposition of chromite ore in molten potassium hydroxide. International Journal of Mineral Processing, 2007, 83: 60-67.

(29) Zhi Sun, Shi-Li Zheng, Yi Zhang. Investigation of efficient conditions for oxidative roasting of chromite ore to produce potassium chromate with KOH additive. Steel Research International, 2007, 78 (7): 574-576.

(30) XU Hongbin, ZHANG Yi, YOU Haixia. Separation of potassium chromate by salting-out crystallization. Journal of Chemical Industry and Engineering (China), 2007, 58 (4): 930-937.

(31) WANG Jiong, XU Hong-bin, ZHANG Song-pei, ZHANG Yi. Experimental investigation on separation of potassium chromate from its aqueous solution by solventing-out crystallization. The Chinese Journal of Process Engineering, 2007, 7 (2): 246-251.

(32) H.-B. Xu, S.-L. Zheng, Y. Zhang, Z.-H. Li, Z.-K. Wang. Oxidative leaching of a Vietnamese chromite ore in highly concentrated potassium hydroxide aqueous solution at 300°C and atmospheric pressure. Minerals Engineering, 2005, 18 (5): 527-

535.

(33) Xu Hongbin, Zhang Yi, Zheng Shili. The application of the second (salting-out) crystallization process in the potassium chromate cleaner production. Journal of chemical industry & engineering, 2003, 24 (2): 1-4.

(34) ZHENG Shili, ZHANG Yi. Corrosion performance of materials in chromite oxidation process with molten NaOH. Corrosion science and protection technology, 2001, 13 (4): 230-233.

(35) YANG Renchun, HE Lihui, LI Zuohu, ZHANG Yi. Separation of Na_2CrO_4 and NaCl. Inorganic chemicals industry, 2001, 33 (9): 5-7, A1.

(36) Zou Xing, Zhang Yi. The effect of Na_2CrO_4 on $NaAl(OH)_4$ solution hydrolysis. Environmental chemistry, 2000, 19 (5): 470-473.

(37) Zou Xing, Zhang Yi. The separation of sodium aluminate impurities from sodium chromate in crystal. Environmental chemistry, 2000, 19 (2): 149-153.

(38) Ping Li, Hong-Bin Xu, Yi Zhang, Zuo-Hu Li, Shi-Li Zheng, Yu-Lan Bai. The effects of Al and Ba on the colour performance of chromic oxide green pigment. Dyes and Pigments, 2009, 80 (3): 287-291.

(39) Zhenzhao Pei, Hongbin Xu, Yi Zhang. Preparation of Cr_2O_3 nanoparticles via C_2H_5OH hydrothermal reduction. Journal of Alloys and Compounds, 2009, 468 (1-2): L5-L8.

(40) YOU Haixia, XU Hongbin, ZHANG Yi, LI Zuohu, ZHENG Shili, BAI Yulan. Kinetics of hydrogen reduction of sodium chromate. CIESC Journal, 2009, 60 (3): 649-653.

(41) Yu-Lan Bai, Hong-Bin Xu, Yi Zhang. Synthesis and characterization of ultra-fine Cr_2O_3 prepared from hydrogen reduction of K_2CrO_4. Journal of Wuhan University of Technology, Materials Science Edition, 2008, 23 (2): 181-183.

(42) Zhenzhao Pei, Yi Zhang. A novel method to prepare Cr_2O_3 nanoparticles. Materials Letters, 2008, 62: 504-506.

(43) Li Ping, Xu Hongbin, Zhang Yi, Li Zuohu, Zheng Shili. Chromic oxide green pigment prepared by hydrogen reduction and activated sintering method. Journal of the Chinese rare earth society, 2008, 26 (Spec. Issue): 854-858.

(44) Chengwei Li, Tao Qi, Fu'an Wang, Yi Zhang, Gensheng Chen, Peng Zhang. Macrokinetic study of the electrochemical synthesis process of sodium dichromate. Chemical Engineering & Technology, 2007, 30 (4): 467-473.

(45) BAI Yu-lan, XU Hong-bin, ZHANG Yi, LI Zuo-hu. Application of FT-IR and XPS technique on the analysis of the mixture containing chromium in a low valence state. Spectroscopy and Spectral Analysis, 2007, 27 (4): 675-678.

(46) ZHANG Peng, CAO Hong-bin, XU Hong-bin, ZHANG Yi. Preparation of ultrafine chromia particles by hydrothermal reduction and size control. The Chinese journal of process engineering, 2007, 7 (1): 95-99.

(47) CHEN Gen-sheng, LI Cheng-wei, WANG Fu-an, ZHANG Peng, QI Tao, ZHANG Yi. Variation of operating voltage in the electrosynthesis process of potassium dichromate under different temperature. Henan chemical industry, 2007, 24 (8): 15-17.

(48) Yu-Lan Bai, Hong-Bin Xu, Yi Zhang, Zuo-Hu Li. Reductive conversion of hexavalent chromium in the preparation of ultra-fine chromia powder. Journal of Physics and Chemistry of Solids, 2006, 67 (12): 2589-2595.

(49) Chengwei Li, Tao Qi, Fu'an Wang, Yi Zhang, Zhihui Yu. Variation of cell voltage with reaction time in electrochemical synthesis process of sodium dichromate. Chemical Engineering & Technology, 2006, 29 (4): 481-486.

(50) LI Yu-ping, ZHANG Yi, QI Tao, LIU Ke-ling. Determination of impurities in $K_2Cr_2O_7$ by an inductively coupled plasma spectrometer. Spectroscopy and Spectral Analysis, 2004, 24 (11): 1428-1431.

(51) CHEN Heng-fang, LI Zuo-hu, ZHANG Yi, LI Hu-quan. Phase diagram analysis of a new cleaner process for making chromium trioxide and potassium nitrate simultaneously. The Chinese journal of process engineering, 2004, 4 (6): 577-582.

(52) Chen Hengfang, Li Huiquan, Li Zuohu, Zhang Yi. A new cleaner process for making chromium trioxide and potassium nitrate simultaneously. Chemical industry and engineering progress, 2004, 23 (3): 307-310.

(53) Chen Hengfang, Li Zuohu, Zhang Yi, Li Huiquan. Cleaner production for making chromium trioxide based on green chemistry theory. Environmental protection, 2004, (10): 19-21.

(54) Zhi-mao Yao, Zuo-hu Li, Yi Zhang. Studies on thermal dehydration of hydrated chromic oxide. Journal of Colloid and Interface Science, 2003, 266: 382-387.

(55) YAO Zhi-mao, LI Zuo-hu, ZHANG Yi. Experiments on reducing potassium chromate and potassium dichromate to chromic oxide hydrate under hydrothermal conditions. The Chinese journal of process engineering, 2003, 3 (1): 62-67.

(56) LIU Chang-jian, ZHANG Yi. Crystals in conversion process of sodium chromate with ammonia and carbon dioxide. Inorganic chemicals industry, 2003, 35 (6): 20-21, 48.

(57) YAO Zhimao, LI Zuohu, ZHANG Yi. Study on preparation of hydrated chromic oxide and its thermal decomposition. Journal of the Chinese ceramic society, 2002, 30 (Supplement): 116-119, 123.

(58) LIU Changjian, ZHANG Yi,LI Zuohu, CUI Jinlan. Reaction process of sodium chromate with carbon dioxide and ammonia. Engineering chemistry & metallurgy, 1999, 20 (4): 410-414.

(59) Shaona Wang, Shili Zheng, Yi Zhang. Stability of $3CaO{\cdot}Al_2O_3{\cdot}6H_2O$ in $KOH+K_2CO_3+H_2O$ system for chromate production. Hydrometallurgy, 2008, 90 (2): 201-206.

(60) WANG Shao-na, ZHENG Shi-li, ZHANG Yi. Separation of aluminum and silicon in cleaner production process for potassium chromate. The Chinese Journal of Nonferrous Metals, 2007, 17 (7): 1188-1194.

(61) DU Chun-Hua, ZHANG Yi, ZHENG Shi-Li, HONG Tao. Study on the effective separation of potassium chromate and potassium carbonate (II. Experimental

investigation on the crystallization process). Science and technology in chemical industry, 2007, 15 (6): 5-8.

(62) DU Chun-Hua, ZHANG Yi, ZHENG Shi-Li, HONG Tao. Study on the effective separation of potassium chromate and potassium carbonate (Ⅰ. Phase diagram analysis and solubility calculation). Science and technology in chemical industry, 2007, 15 (5): 1-5.

(63) QU Jing-kui, ZHENG Shi-li, XU Hong-bin, QI Tao, ZHANG Yi. Separation of impurities from liquid phase oxidation product of chromite and recycle of caustic potash solution. Hydrometallurgy of China, 2007, 26 (4): 193-197.

(64) Xu Hongbin, Zhang Yi, Li Zuohu, Li Huiquan. Separation of aluminum in the clean production process for potassium dichromate. Chemical industry and engineering progress, 2003, 22 (1): 46-48.

(65) Yao Zhimao, Li Zuohu, Zhang Yi. Recovery of caustic potash in new technology of cleaner production of chromic oxide. Chemical industry and engineering progress, 2002, 21 (11): 864-867.

(66) YANG Ren-chun, HE Li-hui, LI Zuo-hu, ZHANG Yi. Preliminary study on the carbonation of K_2CrO_4 for recovery of potassium alkali in alkaline solution. The Chinese journal of process engineering, 2001, 1 (4): 422-426.

(67) DAI Hao-bo, CAO Hong-bin, LI Yu-ping, ZHANG Yi. Acid leaching and bio-leaching of chromite ore processing residue. The Chinese journal of process engineering, 2006, 6 (1): 55-58.

(68) SUN Zhi, ZHENG Shili, ZHANG Yi. Experimental research on the resourceful disposal of chromium-containing residues in cleaner production technology of chromates. Multipurpose utilization of mineral resources, 2005, (6): 36-39.

(69) WANG Wan-ping, ZHANG Yi. Comprehensive utilization of chromic residues in cleaner production of chromic salts. Modern Chemical Industry, 2002, 22 (9): 27-29.

(70) QI Tao, ZHANG Yi, GUO Yuehua, LI Zuohu, WANG Zhikuan. A novel green process of zero emission of chromium-containing residues. Engineering chemistry

and metallurgy. 1999, 20 (1): 92-97.

Patent Applications:

(1) Clean production of sodium chromate, Publication No. CN 1226512

(2) Clean production process of ammonium chromate crystal, Publication No. CN1310132

(3) Method of preparing chromium oxide using precarbonation wet reducing potassium chromate or sodium chromate, Publication No. CN 1410356

(4) Method of preparing chromium oxide using wet reducing potassium bichromate or sodium bichromate, Publication No. CN1410357

(5) Process for preparing magnesium carbonate whisker, Publication No. CN1463923

(6) Nano dichromium dioxide catalyst for preparing ethylene by using carbon dioxide to oxidate ethane and dehydrogenation, Publication No. CN1515354

(7) New cleaning technology of chromic acid anhydride and nitric acid anhydride joint production, Publication No. CN1493525

(8) Method for preparing calcium chromate, Publication No. CN 1519203

(9) Production method of potassium dichromate, Publication No. CN1565979

(10) METHOD FOR PRODUCTION OF ALKALI METAL CHROMATES, Publication No. WO2004083123

(11) Method of preparing chromium oxide by reducing chromate with gaseous reducing agent at low temperature, Publication No. CN 1907865

(12) Chromium slag processing method for chemical-biological coupling reduction of hexavalent chrome, Publication No. CN1962096

(13) Chromic slag treatment method of detoxifying hexavalent chromium directly by biologic method, Publication No. CN1733375

(14) Process for preparing high specific surface area chromium catalyst utilizing microbes, Publication No. CN1733359

(15) Basicity controllable poly ferric sulfate preparation method, Publication No. CN1800032

(16) Method for preparing soda from reussin, Publication No. CN1490247

(17) Method for preparing colour terraalba from waste gypsum containing chromium, Publication No. CN1508088

(18) Process for preparing magnesia whisker, Publication No. CN1463922

(19) Method of preparing light magnesium carbonate from heavy magnesium water, Publication No. CN1410351

(20) Comprehensive utilization method of converting chromium slag totally into light magnesium carbonate and fine iron breeze, Publication No. CN1410352

9. Below is a certificate of Chinese National Technology Invention Award for The invention of "METHOD FOR PRODUCTION OF ALKALI METAL CHROMATES".

国家技术发明奖

证 书

为表彰国家技术发明奖获得者，特颁发此证书。

项目名称：铬盐清洁工艺与集成技术

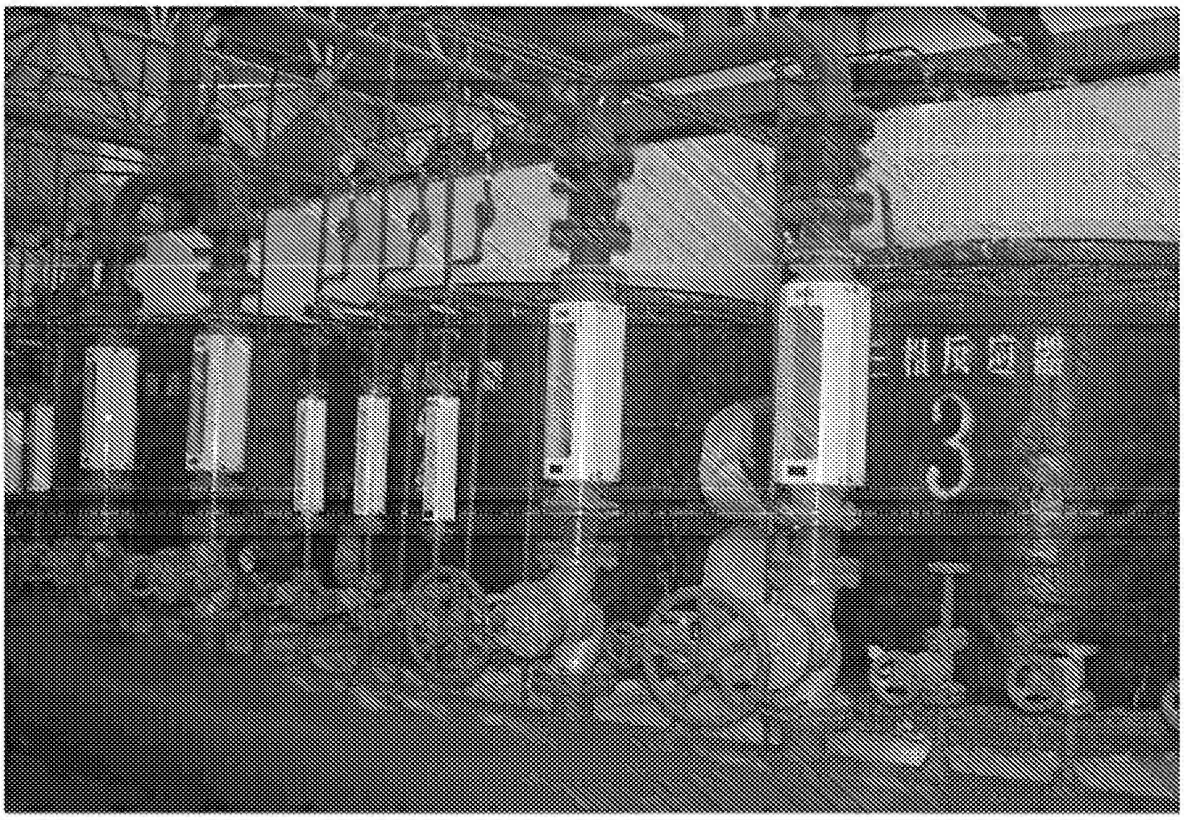
奖励等级：二等

获 奖 者：郑诗礼(中国科学院过程工程研究所)

证书号：2005-F-231-2-01-R04

10. Below are pictures of the industrial application of the invention of "METHOD FOR PRODUCTION OF ALKALI METAL CHROMATES".

(1) A picture of the unit for decomposing chromite ore:



(2) A picture of the plant for potassium chromate separation:

(3) A picture of the factory:

11. The Okabe '412 patent has the following shortcomings:

(1) The Okabe '412 patent requires chrome ore to react with a melting alkali metal hydroxide by using a nitrogen oxyacid as an oxidant, and requires a reaction temperature of more than 400 °C, due to a eutectic temperature required for melting the mixture of the alkali metal hydroxide and the nitrogen oxyacid. If the reaction temperature is below 400 °C in Okabe '412's system, the alkali metal hydroxide and the nitrogen oxyacid can not be formed in a molten state, and the chrome ore can not be effectively decomposed even for a prolonged reaction time.

(2) The Okabe '412 patent uses nitrogen oxyacid as an oxidant. The amount of nitrogen oxyacid required for decomposing chromite ore is based on a stoichiometric amount (see the following reaction formulae:

$$5Cr_2O_3(\text{in ore}) + 14MOH + 6MNO_3 \rightarrow 10M_2CrO_4 + 3N_2 + 7H_2O$$

$$Cr_2O_3(\text{in ore}) + 2MOH + 2MNO_2 \rightarrow 2M_2CrO_4 + N_2 + H_2O$$

wherein M is an alkali metal, such as Na, Ka or Li.

Due to the high price and large amount of nitrogen oxyacid required for the reaction, the Okabe '412's technology is not economical to achieve industrial applications.

12. Our invention is different from the Okabe '412 patent in the following aspects:

(1) Our invention uses the reaction of potassium hydroxide solution and chromite ore, with air as an oxidant. A small amount of water is present in the reaction system. Therefore, even at low temperatures, the potassium hydroxide can exist in a liquid state. Therefore, the reaction temperature can be reduced to 400 °C. See the amended claim 21:

> "reaction temperature is in a range of from 200 °C to 350 °C".

(2) Our invention uses air or oxygen as an oxidant. Because air is cheap and easy to obtain, it is more suitable for industrial applications and will not generate dangerous gases. In fact, in our current production lines, compressed air is used as the oxidant. The reaction formula is as follows:

$$Cr_2O_3(\text{in ore}) + 4MOH + 1.75O_2 \rightarrow 2M_2CrO_4 + 2H_2O$$

See the amended claim 23:

"wherein said oxidant is air or oxygen."

13. Both of CN 1240763 and CN 1226512 are Chinese patents. CN 1226512 was applied by our institute, and CN 1240763 was applied by a company that used to collaborate with us. Both of the CN 1240763 and CN 1226512 patents produce sodium chromate. The CN 1226512 patent uses air as the oxidant, and focuses on the separation step between the sodium chromate and sodium aluminate. The CN 1240763 patent uses pure oxygen as the oxidant, and focuses on the description of the process flow. Our present invention produces potassium chromate, and was developed based on the CN 1240763 and CN 1226512 patents that produce sodium chromate.

14. Our invention is different from the CN 1240763 and CN 1226512 patents in the following aspects:

(1) Both of the CN 1240763 and CN 1226512 patents produce sodium chromate, which requires a relatively high reaction temperature of 500 to 600 °C. On the other hand, our present invention produces potassium chromate which requires a reaction temperature that is about 200 °C lower than the reaction temperature required for producing sodium chromate. Due to the high reaction temperature required for producing sodium chromate, the life time for the core manufacturing equipment is relatively short. In less than three month, the flange gasket of the reactor for producing sodium chromate was corroded, and could not be used. Therefore, we had to reach on the production of potassium chromate. Now, the manufacturing equipment for producing the potassium chromate, which is built in accordance with the present invention, has been running for more than five years, and is still running. See the amended claim 21:

"reaction temperature is in a range of from 200 °C to 350 °C".

(2) The separation process for sodium chromate in the CN 1240763 and CN 1226512 patents and the separation process for potassium chromate in our invention are different from each other. In the CN 1240763 and CN 1226512 patents, the solubility of sodium chromate in sodium hydroxide solution is relatively high, but the solubility varies largely with temperature. Therefore, the CN 1240763 and CN 1226512 patents use a cooling crystallization method to separate the sodium chromate from the sodium hydroxide solution, and thus obtaining sodium chromate crystal with a high crystallization ratio of about 55%. On the other hand, in our invention, the solubility of potassium chromate in the potassium hydroxide solution is small. If the potassium chromate is separated from the potassium hydroxide solution using the cooling crystallization method as taught by the CN 1240763 and CN 1226512 patents, the crystallization rate for potassium chromate crystal would be about 17%, which is very low. Therefore, our invention uses an evaporation crystallization method to separate the potassium chromate from the potassium hydroxide solution, thus obtaining the potassium chromate crystal with a high crystallization rate of about 95.8%. See the amended claim 22 (emphasis added):

> "separating potassium chromate from the pure potassium chromate aqueous solution using an **evaporation crystallization method** by heating the pure potassium chromate aqueous solution to evaporate water from the pure potassium chromate aqueous solution to obtain potassium chromate crystal precipitates and a mother liquor, filtering the potassium chromate crystal precipitates from the mother liquor and drying the potassium chromate crystal precipitates to obtain the high purity potassium chromate crystal."

I HEREBY DECLARE that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements are made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under §1001 of Title 18 U.S. Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

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